Accelerating Infrastructure Innovations

FOCUS on the Environment

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April 2004

INSIDE

U.S. Department of Transportation

Federal Highway Administration

Recycled Concrete Study Identifies Current Uses, Best Practices

The Federal Highway Administration's (FHWA) Pavement Recycling Team recently completed a year-long review of recycled concrete aggregate (RCA) state-of-the-practice use by five State transportation departments. "The review's goal was to identify the current state of use and then transfer that knowledge to other State highway agencies," says Jason Harrington of FHWA.

The Texas Department of Transportation (TxDOT) has been using RCA in portland cement concrete highways and streets and as a base material for the past 10 years and has found that it provides engineering, economic, and environmental benefits. In addition to eliminating the need for solid waste to go to landfills, RCA primarily is generated and used within the same urban areas. In Houston, for example, the total amount of concrete rubble generated is being consumed as RCA. This saves time and money when compared to hauling aggregrate from quarries.

TxDOT's use of RCA in new concrete initially created problems with mix workability, with contractors having difficulty in maintaining a consistent and uniform saturated surface dry condition. This hurdle was overcome through the implementation of a process control program that heightened awareness of the need to water RCA stockpiles and to conduct more frequent testing of the aggregate for moisture content.

Through training and information sessions for its districts, TxDOT has also worked to overcome the initial general perception in the State that RCA is a waste product and thus substandard material.

Among the recommendations found by the FHWA study for using RCA is that compaction of RCA in a base should be in a saturated state to aid in the migration of fines throughout the mix. It is also recommended that steel wheel rollers be used to compact RCA, as minor amounts of steel present in the material can interfere with rubber-tired equipment.

Since 1983, the Michigan Department of Transportation (MDOT) has used RCA in numerous road projects. Currently, US-41 in Michigan's Upper Peninsula is being reconstructed using RCA as the base material. RCA is also being used as a base material on two projects in the Detroit area. MDOT's experience has shown that RCA used in base and subbase material can provide performance comparable to or better than using virgin aggregate. This is due to the cementitious action that can still occur within the compacted base, adding higher supporting strength for the highway.

MDOT has also found that incorporating RCA can reduce costs. Using RCA for the US-41 reconstruction project has resulted in savings of $114,000, for example.

MDOT notes that quality control and quality assurance procedures are vital when using RCA. Among the areas MDOT is looking to gain additional experience in are RCA's effect on drainage systems and documentation of RCA's long-term performance as a base material.

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Recycled Concrete,

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The University of New Hampshire's Recycled Materials Resource Center (RMRC), in conjunction with the AASHTO Recycling Task Force and the FHWA Recycling Team, will present a workshop on the beneficial use of recycled materials in transportation applications from September 12–14, 2004, in Manchester, New Hampshire. The workshop will bring together State highway agency materials engineers and environmental specialists, State environmental protection agency staff, and FHWA Division Office personnel from 11 northeastern States to discuss the use of recycled materials in the highway environment. "The workshop will be structured to give attendees a tool box of information so as to allow them to develop their own recycling expertise in their State," says Jason Harrington of FHWA. "We hope this will provide a pattern for other regional workshops that will teach participants about the uses of various recycled materials that are sound both environmentally and in an engineering sense."

The RMRC workshop will focus on four particular recycled materials applications: 1) Coal fly ash as a cementation replacement, 2) Foamed bitumen for stabilized full-depth reclamation, 3) Asphalt shingles in asphalt, and 4) Recycled concrete aggregate as a base material.

For more information about the workshop, contact Taylor Eighmy at RMRC, 603-862-1065 (email: t.eighmy@rmrc.unh.edu).

For indepth technical knowledge of asphalt pavement recycling methods, sign up for the National Highway Institute (NHI) course, Asphalt Pavement Recycling Technologies (Course No. 131050A). The course was developed by FHWA, the Asphalt Recycling and Reclamation Association, and the National Center for Asphalt Technology. Among the topics covered are performance of recycled mixes, selection of pavement for recycling, structural design of recycled pavements, recycling strategies, and the economics of recycling.

Upon completion of the course, participants will be able to:

- Describe the various methods (hot and cold) of recycling pavements.
- Determine when asphalt recycling is a viable pavement rehabilitation alternative.
- Select the most appropriate asphalt recycling method or technique.
- Identify materials and mix design for recycled pavements.
- Specify equipment, construction methods, and quality control/quality assurance procedures involved in recycling.
- Demonstrate design methods for hot and cold recycled pavements.

The 2-day course is intended for State and local highway officials, administrators, pavement design engineers and technicians, and construction engineers and inspectors involved in the recycling of asphalt pavements. The cost is $270 per participant.

To schedule the course, contact Danielle Mathis-Lee at NHI, 703-235-0528 (email: danielle.mathis-lee@fhwa.dot.gov). For technical information about the course, contact Jason Harrington at FHWA, 202-366-1576 (email: jason.harrington@fhwa.dot.gov).

The Virginia Department of Transportation's (VDOT) use of RCA has been limited to date. In one application, VDOT used RCA in the subbase aggregate for a $140 million reconstruction of a section of Interstate 66 in Fairfax and Prince William counties. Portable concrete crushing equipment was set up in the work zone at a closed truck weighing station. This eliminated the need to truck aggregate to the construction zone.

The Minnesota Department of Transportation (Mn/DOT) uses almost 100 percent of the concrete removed from its pavements as dense graded aggregate base, with Statewide use of RCA permitted by the Mn/DOT Standard Specifications for Construction. Minnesota has observed that RCA used in base and subbase material performs similarly to virgin aggregate. Research is now underway to establish laboratory performance parameters for RCA used in aggregate for bases and subbases.

The California Department of Transportation's (Caltrans) current specifications allow use of RCA in pavement supporting layers. Caltrans is working with the concrete and aggregate industries to develop further applications of RCA. Caltrans has found that even though the initial production cost of RCA may be higher than that of new aggregate, the location of RCA plants near project areas lowers the final cost of using RCA, primarily due to reduced hauling and overhead costs. This also saves time and reduces the damage to highways from loaded trucks.

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Recycled Plastic Soil Nails Provide Boost to Missouri Slope Stabilization Project

Soils for highway embankments often deteriorate over time because of repeated wet-dry and freeze-thaw cycling. This eventually leads to recurring surface slope failures when the strength of the soil deteriorates to the point where it can no longer maintain stability. A popular technique for stabilizing new embankments or strengthening older slopes is soil nailing, which reinforces the earth slopes with arrays of slender pins driven or drilled into the soil. The pins support tensile loads and create a stronger soil mass overall. In an ongoing project, the Recycled Materials Resource Center (RMRC) at the University of New Hampshire is working with the Missouri Department of Transportation (MoDOT) and the University of Missouri–Columbia (UMC) to evaluate pins made from recycled plastics as a replacement for traditional pins made with steel and grout.

The recycled plastic pins (RPP) measure 90 mm by 90 mm by 2.4 m (3.5 in by 3.5 in by 8 ft). The project's design methodology estimates the resistance provided by each pin and then incorporates it into conventional slope stability analyses to calculate the improvement in the safety factor under various reinforcement scenarios. The objective is to determine the resistance that can be provided by an individual pin and, based on this, the number of pins required to increase the stability of a slope to an acceptable level. One difference when using recycled plastics is that modifications must be made to account for the reduced strength and increased ductility and creep exhibited by plastic materials.

Four field test sites have been established in Missouri since December 1999 to evaluate the load transfer mechanisms between the soil and reinforcement pins and the overall effectiveness of using RPP. An additional site was stabilized with similar-sized steel pipes for comparison. At three of the sites, several different reinforcement patterns have been used to determine how the reinforcing scheme and spacing impacts the effectiveness of the stabilization.

One test site near the town of Emma, Missouri, on Interstate 70 has been in place for 4 years, providing the most field performance data. The clay soil slopes at this site have experienced recurring surface slides over the past decade. Previous stabilization attempts were unsuccessful. Two areas at the site had RPP installed, while two other areas were simply regraded to serve as control sections. On one slope, 199 pins were installed perpendicular to the slope face, while on the other, 163 pins were installed vertically.

> "All of the stabilized slopes are performing well and the instrumentation indicates that the pins have significant remaining capacity to maintain the stability of the slopes."

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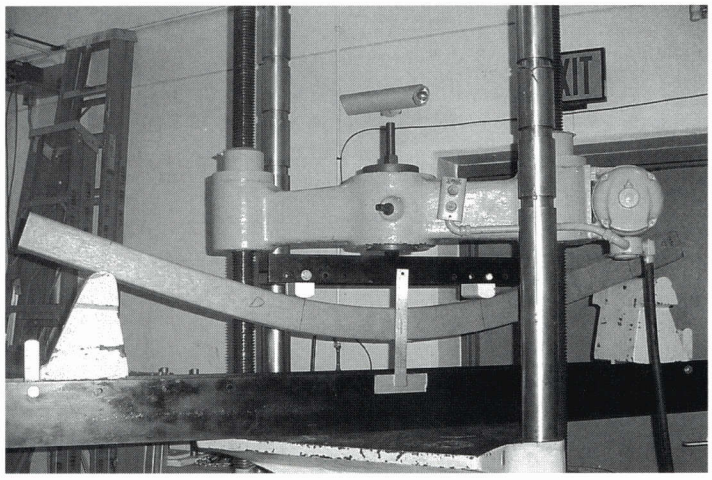


Four-point bending tests are performed on recycled plastic pins.

Recycled plastic pins are driven into a slope using the percussion hammer from a track-mounted drilling rig.

Fly Ash Finds Multiple Uses in Highway Construction

Now available from the Federal Highway Administration (FHWA) is the fourth edition of *Fly Ash Facts for Highway Engineers* (Publication No. FHWA-IF-03-019). Produced in cooperation with the American Coal Ash Association and the U.S. Environmental Protection Agency, the publication provides basic technical information about the many ways that fly ash can be used in highway construction.

Fly ash is the finely divided residue that results from the combustion of pulverized coal. It is a by-product produced by coal-fired electric and steam generating plants. More than 61 million metric tons (68 million tons) of the waste product were generated in 2001. Currently, more than 20 million metric tons (22 million tons) of fly ash are being used annually for various engineering applications. Among the highway engineering uses are for portland cement concrete (PCC), soil and road base stabilization, flowable fills, grouts, structural fill, and asphalt filler. To be used in concrete, fly ash must meet the requirements of American Association of State Highway and Transportation Officials Standard M295, or ASTM International Standard C618. For use in stabilized bases, fly ash needs to meet the requirements of ASTM C593.

Currently, more than 20 million metric tons (22 million tons) of fly ash are being used annually for various engineering applications.

Fly ash can be used in PCC to enhance the performance of the concrete. The fly ash reacts chemically with the lime in PCC to form additional cementitious materials, thus improving many of the properties of the concrete. Some of the resulting benefits are:

- Higher ultimate strength
- Increased durability
- Improved workability
- Reduced bleeding
- Increased resistance to sulfate attack
- Increased resistance to alkali-silica reactivity
- Reduced shrinkage.

Using fly ash in PCC can also lower costs, as a highway agency can reduce the amount of portland cement used. Typically, 15 to 30 percent of the portland cement is replaced with fly ash. And the use of fly ash reduces the amount of waste deposited in landfills, providing an important environmental benefit.

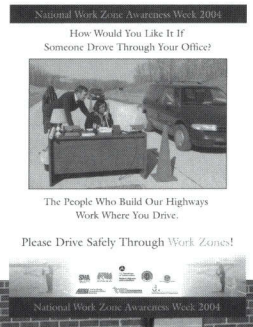
One area of concern to be aware of when using fly ash in PCC is that fly ash concrete mixes typically have a lower early age strength. This lower age strength gain may require that forms be strengthened to mitigate hydraulic loads. However, the lower early strengths can be overcome by using accelerators in the mix. Construction schedules should also allow time for fly ash concrete mixes to gain adequate strength before winter, as strength gain of the concrete is lower at colder temperatures. To keep the temperature of the concrete higher and increase the strength gain, enclosures, heated curing, or insulation blankets can be used.

Another area of concern is that during construction, concrete loads delivered to the project site should be checked for entrained air to ensure that a consistent air content is maintained.

Fly ash can also be used in stabilized base courses. The typical fly ash content for a base course ranges from 12 to 14 percent. Advantages include increased strength and durability and lower costs. Another application is to use fly ash in fills and embankments, ranging from small fills for road shoulders to large fills for Interstate highway embankments. Employing fly ash offers several advantages over using soil and rock, including being more cost-effective and easier to handle and compact. Potential cautions include that dust control and erosion prevention measures must be used and environmental impacts on any nearby groundwater must be considered.

To learn more about the many uses for fly ash in highway engineering, consult *Fly Ash Facts for Highway Engineers,* which can be found online at www.fhwa.dot.gov/pavement/fatoc.htm. Printed copies or a CD version can be ordered from the American Coal Ash Association at 720-870-7897 (www.acaa-usa.org/store-books.htm). FHWA will also be sponsoring six 1-day workshops in 2004 and early 2005 on the use of fly ash in PCC and embankments. For more information on *Fly Ash Facts* or the upcoming workshops, contact Michael Rafalowski at FHWA, 202-366-1571 (email: michael.rafalowski@fhwa.dot.gov).

National Work Zone Awareness Week 2004: Driving for Safety



This photo shows the National Work Zone Memorial on display at the Stafford County, VA, courthouse in 2003.

How would you like it if someone drove through your office? The Federal Highway Administration (FHWA), American Traffic Safety Services Association (ATSSA), American Association of State Highway and Transportation Officials, and other partners will kick off National Work Zone Awareness Week (NWZAW) on April 6 by asking that question at a media event in Springfield, Virginia. FHWA Administrator Mary Peters will speak from a desk located next to Interstate 95, reminding motorists that roadways are workplaces for thousands of employees. "We're asking drivers to remember that most of us get to work in a safe environment, but for thousands of men and women, their office is the highway," says Ann Walls of FHWA's Office of Safety.

In 2002, 1,181 people were killed in motor vehicle crashes in work zones and more than 52,000 people were injured. Since 1997, work zone fatalities have increased more than 55 percent. "It's not just workers who are at risk," says Walls. "Four out of five work zone fatalities are drivers and passengers."

The National Work Zone Memorial will be on display at the April 6 event. Created by ATSSA, the portable Memorial is inscribed with the names of 824 people who lost their life in work zones. Since 2001, the Memorial has visited 18 States and the District of Columbia, raising public awareness of the need to travel cautiously through work zones. "Everywhere that it goes, people stop and talk about it and ask questions. It helps keep the issue of work zone safety in the public eye year round," says Jim Baron of ATSSA.

The Memorial visited Phoenix, Arizona, at the end of March and was featured in a ceremony at the State Capitol on March 23. The Arizona Department of Transportation (ADOT) will then kick off NWZAW 2004 on April 2 with a presentation at an elementary school in Phoenix explaining work zones and their dangers. On April 3, ADOT employees will participate in a Safety Fair at a local mall. Arizona's NWZAW events will culminate with a news conference in Phoenix on April 5, bringing together representatives from the Governor's office, State highway department, State police, FHWA, local contractors, and the traffic services industry.

In Connecticut, the Connecticut Department of Transportation will spotlight NWZAW at a press conference on April 2 with Lieutenant Governor M. Jodi Rell. Connecticut is also launching a new work zone safety campaign, "Slow Down for Them or You Will Stop for Us."

Meanwhile, the Virginia Department of Transportation (VDOT) will call attention to the dangers of traveling through work zones at press conferences in many of its nine districts during NWZAW 2004. VDOT workers will also hand out work zone safety information at all of the State's rest areas and, in conjunction with the Virginia Road and Transportation Builders Association (VRTBA), will visit high school driver education classes across the State to conduct work zone safety training. "It means more hearing the message from someone who faces the dangers everyday than from a teacher who lacks the experience of being in a work zone," says David Rush of VDOT. Last year, this effort reached 5,000 high school students, with VDOT and VRTBA aiming to increase that number to 10,000 this year.

Virginia is also planning the construction of a VDOT Workers' Memorial, which will commemorate the 96 State highway transportation workers killed on the job since 1927. The Memorial will be located off of I-64 near Afton Mountain. To learn more about the Memorial, visit www.virginiadot.org/infoservice/isworker-memorial.asp.

For more information about NWZAW 2004 or FHWA's work zone safety initiatives, contact Ann Walls at FHWA, 202-366-6836 (email: ann.walls@fhwa.dot.gov), or visit safety.fhwa.dot.gov/wzs/nwzsweek04.htm. To learn more about the National Work Zone Memorial, contact Vicki Lindberg at ATSSA, 540-368-1701, ext. 150. For more information on work zone safety efforts across the country, visit the National Work Zone Safety Information Clearinghouse at wzsafety.tamu.edu. *

Recycled Plastic,
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The site has been monitored for lateral movements, pore pressures, strains within the reinforcing pins, and lateral loads applied to the pins. "All of the stabilized slopes are performing well and the instrumentation indicates that the pins have significant remaining capacity to maintain the stability of the slopes," says project lead investigator Erik Loehr, an Assistant Professor at the University of Missouri-Columbia. In contrast, both control sites failed in spring 2001, during a period of higher than normal rainfall. While the RPP showed increased bending around the time of the control slope failures, they continue to provide reinforcement to the slope. To date, the vertically-oriented pins have provided better resistance to bending. The performance of the comparison site reinforced with similarly-sized steel pins has been similar.

The study has also looked at the long-term durability of RPP when subjected to various environmental conditions, such as exposure to freeze-thaw cycles and ultraviolet rays. Results of these tests indicate that the RPP are very durable. In general, plastics are much less susceptible to degradation when buried than timber, steel, or even concrete.

The field demonstration sites are now being used to evaluate the load transfer mechanisms in different slope conditions and to ascertain whether wider pin spacing can be used to reliably stabilize slopes. One problem that MoDOT and its partners have encountered is that there are dozens of manufacturers that produce plastic pins using different material formulations and processing techniques. This results in significant variability in the engineering properties of different pins. In addition, there are few common specifications for quantifying and reporting pin performance, so that different manufacturers characterize their pins using different criteria.

The field demonstration sites are now being used to evaluate the load transfer mechanisms in different slope conditions and to ascertain whether wider pin spacing can be used to reliably stabilize slopes.

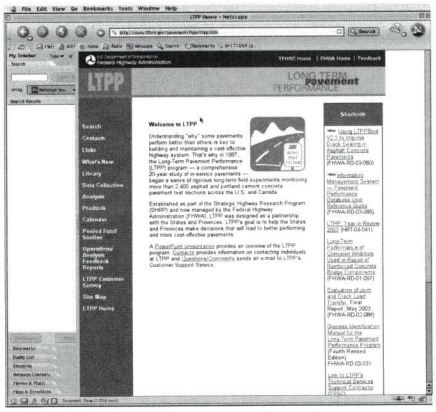
To help solve this problem, MoDOT and UMC are conducting uniform laboratory and field tests on different pins so that their properties can be directly compared. In the laboratory, uniaxial compression, 4-point bending, and accelerated creep tests are being used to characterize the mechanical behavior of the material, while field tests will evaluate the key issue of "drivability," or how well the pins can be inserted into the soil. Once this research is complete, the laboratory and field data, along with the data from the demonstration sites, will be used to develop standards and guidance documents, including a guidance specification for MoDOT and a recommendation to the American Association of State Highway and Transportation Officials for a recycled plastic soil pin specification.

For more information about the project, contact Tom Fennessey at MoDOT, 573-526-4340 (email: thomas.fennessey@modot.mo.gov), Erik Loehr at UMC, 573-882-6380 (email: eloehr@missouri.edu), or Taylor Eighmy at RMRC, 603-862-1065 (email: t.eighmy@rmrc.unh.edu). *

In Brief...

The Federal Highway Administration's (FHWA) Office of Asset Management is now offering a 1-day workshop for State and local governments on **Economic Analysis for Highway Decision Makers.** The free workshop covers a broad range of economic subjects, including inflation, life-cycle cost analysis, benefit-cost analysis, traffic forecasts, and risk analysis. No prior training in economics is required. For more information, contact your local FHWA Division Office or Eric Gabler at FHWA, 202-366-4036 (email: eric.gabler@fhwa.dot.gov).

A new edition of data from the **Long-Term Pavement Performance (LTPP) Program database, Standard Data Release 17,** is available from FHWA. Data Release 17, which comes on five CD-ROMs, contains the latest LTPP pavement performance data in Microsoft Access® format. The CD-ROMs also include information on how to use the database, as well as a description of what is new since the last data release. To obtain a copy, contact LTPP Customer Support Services at 865-481-2967 (email: ltppinfo@fhwa.dot.gov). *



Highway Technology Calendar

The following events provide opportunities to learn more about products and technologies for accelerating infrastructure innovations.

Making Work Zones Work Better Workshops
April 6–7, 2004, Bangor, ME
April 27, 2004, Sacramento, CA
April 29, 2004, Riverside, CA

The Federal Highway Administration (FHWA), along with State and local partners, is sponsoring this series of workshops to share information on new and emerging technologies and practices for reducing work zone congestion and crashes.

Contact: Carol Keenan at FHWA, 202-366-6993 (email: carol.keenan @fhwa.dot.gov).

2004 Concrete Bridge Conference
May 17–18, 2004, Charlotte, NC

The focus at this conference will be on high-performance concrete bridges and rapid bridge construction. The event is sponsored by the National Concrete Bridge Council, Portland Cement Association, American Concrete Institute, and FHWA.

Contact: Shri Bhide at the Portland Cement Association, 847-972-9100 (fax: 847-972-9101; email: sbhide@cement.org; Web: www.nationalconcretebridge.org/cbc).

First Rubber Modified Asphalt Conference
May 19–20, 2004, Grand Rapids, MI

The conference will provide a forum for discussing the uses of rubber modified asphalt. Topics will include best practices, State and contractor experiences, and environmental considerations. Conference sponsors include the Rubber Pavements Association, Rubber Manufacturers Association, the Rubber Division of the American Chemical Society, and FHWA.

Contact: For registration information, contact WALCOM–Registration Services, 740-524-4123 (fax: 877-848-4123; email: reg@walcom.com).
To learn more about the conference, visit www.rubber.org/meetings/asphalt.htm.

First International Symposium on the Design and Construction of Long Lasting Asphalt Pavements
June 7–9, 2004, Auburn, AL

The symposium will facilitate the exchange of information on materials and mix design, construction issues, quality control/quality assurance, contracting methods, perpetual pavements, and other related topics. Sponsors include the International Society for Asphalt Pavements, the Asphalt Alliance, and FHWA.

Contact: National Center for Asphalt Technology, 334-844-6228 (fax: 334-844-6248; email: taplecp@eng.auburn.edu; Web: www.ncat.us (click on "Upcoming Events")).

Second National Prefabricated Bridges Workshop
September 8–10, 2004,
New Brunswick, NJ

The workshop will look at how the use of prefabricated bridge elements and systems enables bridge owners, designers, and construction contractors to "Get in, Get out, and Stay out." Sessions will cover how prefabricated bridge components can be used to minimize traffic disruption, improve work zone safety, reduce environmental impacts, and improve constructibility while maintaining quality. Various bridge projects featuring prefabrication will also be highlighted. The event is sponsored by FHWA, the American Association of State Highway and Transportation Officials, and the Midwest Transportation Consortium, in cooperation with the University of Missouri–Columbia.

Contact: Charlie Nemmers at the University of Missouri–Columbia, 573-882-0071 (email: nemmersc@missouri.edu), Benjamin Tang at FHWA, 202-366-4592 (email: benjamin.tang@fhwa.dot.gov), or Mary Lou Ralls at the Texas Department of Transportation, 512-416-2183 (email: mralls@dot.state.tx.us).

Structural Materials Technology: NDE/NDT for Highways and Bridges 2004
September 14–17, 2004, Buffalo, NY

Participants will be able to learn about the state-of-the-art in nondestructive evaluation (NDE) and nondestructive testing (NDT) technologies. The event is sponsored by The American Society for Nondestructive Testing, Inc., New York State Department of Transportation (NYSDOT), Transportation Research Board, FHWA, and the Structural Engineering Institute.

Contact: Glenn Washer at FHWA, 202-493-3082 (fax: 202-493-3442; email: glenn.washer@fhwa.dot.gov), or Sreenivas Alampalli at the NYSDOT, 518-457-6827 (email: salampalli@dot.state.ny.us; Web: www.fhwa.dot.gov/bridge/smt.htm).

Second International Conference on Bridge Maintenance, Safety, and Management
October 19–22, 2004, Kyoto, Japan

The conference will adress all major aspects of bridge maintenance, safety, and management, including assessment and evaluation, bridge management systems, nondestructive testing, rehabilitation, maintenance strategies, and service life prediction. Event sponsors include the International Association for Bridge Maintenance and Safety, Transportation Research Board, FHWA, California Department of Transportation, University of Colorado at Boulder, and the Danish Road Directorate.

Contact: For information about the conference, visit iabmas04.kuciv.kyoto-u.ac.jp.

FOCUS

Focus (ISSN 1060-6637), which is published monthly by the U.S. Department of Transportation's Federal Highway Administration (FHWA), covers the implementation of innovative technologies in all areas of infrastructure.

Its primary mission is twofold: (1) to serve the providers of highway infrastructure with innovations and support to improve the quality, safety, and service of our roads and bridges; and (2) to help promote and market programs and projects of the various offices of FHWA's Office of Infrastructure.

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Summaries of the Texas, Michigan, Virginia, Minnesota, and California RCA reviews can be found online at www.fhwa.dot.gov/pavement/recycle.htm. An overall summary report is due to be released later this year. FHWA is also working with the American Association of State Highway and Transportation Officials (AASHTO), U.S. Environmental Protection Agency, and the American Concrete Institute to develop guidance information on how States can use recycled concrete in highway applications. To learn more about the State RCA reviews or the guidance information being developed, contact Jason Harrington at FHWA, 202-366-1576 (email: jason.harrington@fhwa.dot.gov). *

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